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Brainwaves and Sound Synchronisation in Dance Performance

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1. INTRODUCTION

In a previous work (Lucchiari & Folgieri 2015), we considered communication among young people. New digital-natives do not communicate in a traditional way, but they choose different means and ways. It is not a surprising conclusion that a large part of digital-natives considers obsolete both Web sites' structure and Internet navigation modes, learning instruments and paradigms and communication tools, choosing, instead, fast and immediate media like mobile phone communication, social networking and so on (Croitoru et al. 2011). Notwithstanding we could think they lack of communication skills, actually, they communicate with each other much more than ever done, using not only the verbal language, but also images, videos, sounds, and especially emotions. We named this phenomenon telepatheia or, better, sympateia, meaning that they seem to keep in contact independently by the mean. Of course, on our intention, this does not mean that we are observing a new organic evolution, but surely a kind of evolution can be traced: an era in which human and machines are evolving, influencing one each other, determining a specific kind of communication strongly influenced and related to technology.

In this paper, starting from our previous studies and from our concept of "sympateia", we performed a new experiment related to brain rhythms synchronisation. Through our experiment, described in the following section, we wanted to explore the communication mechanisms of telepathy (in the ancient Greek assumption of τελεπατηια that is τελε[tele]="distance" and πατηια [pateia]="emotion, feeling"). This does not mean that we are trying to make humans telepathic, but we aim to deeply understand communication mechanisms among humans through human-computer interaction BCI devices. This means to change the point of view of brain and Information Technology researches, stressing the point of view of self-understanding of the own brain.

2. THE EXPERIMENT: AIMS AND SETUP

According with Dyson Freeman (Freeman 2010), we assumed that new progresses concern radio-telepathy, which is the way to realise a technology-driven communication, joining human and technology, using brain and technological tools to communicate. This future is not so far, considering the application of Brain Computer Interface in neurology. Furthermore, neuro-cognitive studies and the machine learning models of automatic learning, provide a great opportunity to explore the potentiality in communication mechanisms in humans.

Communication is a form of interaction that gives rise to a joint product by mutual participation. During a communicative interaction, participants are on the same level and share the same communication responsibility. Indeed, when people communicate, they must adapt their styles with each other and this lead to a mutual adaptation within a conversation, in which synchronisation naturally occurs with regard to shift timing and rhythms. The emergence of patterns of synchronisation and adaptation is crucial in ensuring effective communication and comprehensibility. Synchronisation is particularly important when communication becomes a tool for the management of relationships, i.e., when communicators act as players of an interactive game (e.g., seduction). In this communication game, meanings become shared as well as the intentions and positions on a virtual communication chessboard. In this sense, communication implies much then information exchanges; hence, in order to understand the psychological value of a communication act is fundamental to understand the whole context of the interaction.

To measure the synchronisation level of brain rhythms in individuals involved in a communication process, we use Brain Computer Interface (BCI) devices. Roughly speaking, a BCI device is a simplification of the medical EEG equipment, collecting brain signals from the scalp of an individual. The device provides means to measure brain neural signal, methods and algorithms to decode cerebral states and intentions related to acquiring signals, methodologies and algorithms to map the decoded cerebral activity into aptitudes or movement intentions.

AI algorithms allow to analyse and interpret the collected brain signal, to detect different mental states of the individuals involved in the communication process, also in real time. We wish to recall the general aspects of AI, making this discipline the most near to neuroscience and brain studies scopes. The commonly accepted definition of AI is that provided by Charniak and McDermott, stating, “Artificial intelligence is the study of mental faculties through the use of computational models” (Charniak & McDermott 1985). Therefore, AI represents a key factor in NeuroInformatics and in BCI-related studies because it provides a large number of cognitive models to represent users and a variety of means to test the models. Additionally, AI offers the possibilities to elaborate intelligent systems that might adapt to the needs of users.

With the aim of find an expression of our concept of “sympateia”, we performed an experiment related to brain rhythms synchronisation, which involved a number of subjects to listen to two different sound tracks. The first one being a track containing frequency beats, slowly changing the pitch. The second sound track is instead a percussive tribal music well cadenced and with concise rhythms. We recorded and observed the brain reactions to the music stimuli to see if any synchronisation occurred. The tools used to record the brain waves is the Neurosky Mindwave, a BCI device which allowed us to retrieve information about the brain rhythms by the frequency range they belong: alpha waves (7 Hz – 14 Hz) associated to meditation, relaxation, contemplation; beta rhythms (14 Hz – 30 Hz), related to attention, active thinking, concentration; the delta band (3 Hz – 7 Hz), associated with continuous attention activity; the theta rhythm (4 Hz – 7 Hz), generally related to emotional engagement; the gamma signal (30 Hz – 80 Hz), usually related to the cognitive interpretation of multi-sensory signals.

2.1 Results

The data obtained from the experiments returned a mixed result, which partially confirmed our initial hypothesis. In particular, by observing the brainwaves graphs of the response to the percussive soundtrack it is possible to see a considerably synchronised waveform on Theta waves, matching on peaks. The other brainwaves do not present a visible synchronisation, except for Alpha rhythms which is however less intense than the Theta one. Since Theta waves are usually associated with discomfort and/or uneasiness this could indicate that the subjects didn’t particularly enjoy the music.

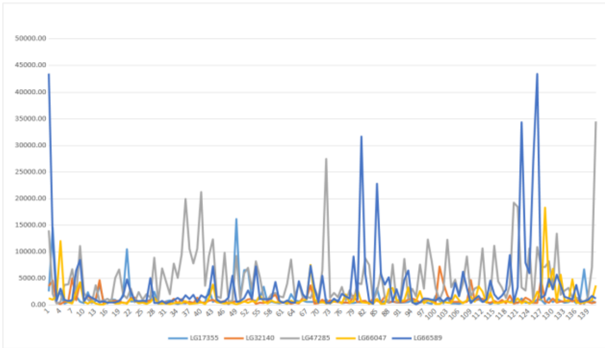

Figure 1*: Theta rhythms (4–7 Hz).*

A different reaction is visible in the graphs for the beats sounds. With the exception of one of the subject, which often has a more intense and unrelated response, the other subjects look well synchronised among them. This is visible for each of the brainwaves, where peaks are matching in time. This is particularly true for Gamma and Beta rhythms (both Low and High), which show this trend. Since neurologically these waves are usually representing decision-making process and complex cognitive functions, it is possible to say that the beats sound affects these aspects more than, for instance, relaxation or imagination processes (Alpha waves). On the other hand, with this type of sound, Theta rhythms does show some synchronisation but not peaks of relevant intensity which is an unexpected result since that would mean the subjects didn’t feel uncomfortable, compared to the percussive sound used in the first experiment.

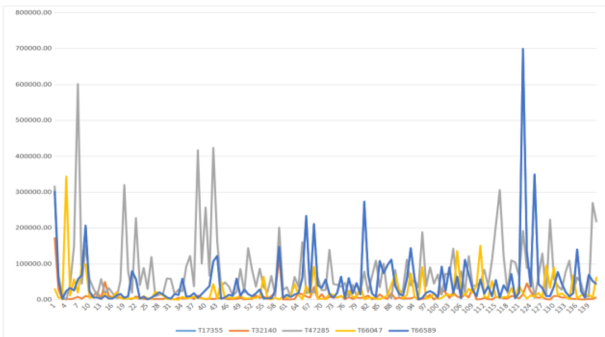

Figure 2*: Low Gamma rhythms (31 – 40 Hz).*

3. CONCLUSION

In our previous studies, experiments show that, after a relatively low time, brain waves, especially those corresponding to beta values, of different users align each other showing similar frequency and amplitudes, with insignificant differences. The same result is obtained if the comparison is done among persons' brain waves and melody waves, obtained rescaling (that is normalising) the sound signal to the same scale of users' ones. We performed some experiments with the aim of finding a kind of alignment in brain rhythms among users, using BCIs, subjected to the same audio stimuli or playing chess game. Positive results encourage our research in designing and developing means allowing Humans to communicate each other using brain mediated by technological devices. In the experiment performed, we were searching for a kind of "sympateia" among users' brains that is to verify if, submitted to the same stimulus, different users show similar brain rhythms response putting them "on the same wavelength".

The data obtained by the analysis of the subjects' brainwaves listening at percussive soundtracks, partially confirmed our initial hypothesis. In particular, Theta rhythms, associated with discomfort have been observed similarly in all the subjects, as, in general Alpha rhythms.

The beats sounds had a different effect on the individuals involved in the experiment: all the subjects showed a general involvement of Gamma and Beta rhythms in strongly similar waves. This means that this kind of sound solicited in all the subject complex cognitive processes, associated with Gamma and Beta brainwaves, showing the same peaks in all the spectra examined.

Of course, these are only preliminary results and we need to confirm the outcomes involving a greater number of subjects in the experiment and analysing data also from a numerical point of view.

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